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APPLICATION

FOR

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TITLE:	METHOD OF PRODUCTION OF SEMICONDUCTOR COMPONENTS
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PRIORITY:	*This application is a divisional application of U.S. Application Serial No. 09/722,461, filed on November 28, 2000, which is a continuation of international application PCT/DE99/01556, filed May 25, 1999, which designated the United States. The entire disclosures of which are incorporated herein by reference.*

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METHOD FOR PRODUCTION OF SEMICONDUCTOR COMPONENTS

SPECIFICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of copending international application PCT/DE99/01556, filed May 25, 1999, which designated the United States.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for manufacturing semiconductor components wherein HF (hydrogen fluoride) soluble masking material is used. The components may be optoelectronic or electronic semiconductor components or laterally integrated semiconductor components wherein electrical and optoelectronic semiconductor components are individually used or combined.

Description of Related Art

It is known in the art that HF soluble layers on an epitaxial substrate, such as a semiconductor substrate, may be chemically (wet or dry) removed outside of an epitaxial reactor. By this method, laterally integrated components may be produced by selective epitaxy or heteroepitaxy.

In selective epitaxy, HF soluble layers are used for masking. Select layers are grown in the epitaxy reactor and thereafter, masked areas are chemically (wet or dry) removed outside of the reactor. For further integration's, additional lithographic steps would be necessary.

In heteroepitaxy, direct semiconductors (connection semiconductors) are applied on a silicon substrate. The natural oxide of the silicon, SiO_2, which is created by the contact of the substrate with oxygen, produces considerable problems. To remove this SiO_2 layer the substrate needs to be exposed to high temperatures in the order of approximately 900°C.

As such, in both methods, the substrate is removed from the reactor and exposed to ambient air. Accordingly, the substrate may be exposed to uncontrolled contamination. By multiple insertions and removals of the substrate into and from the

reactor, the above processes become susceptible to faults, the gain of functional components decreases, and the production costs increase. For example, in heteroepitaxy electrical and optoelectrical components are integrated. In general, the electrical components already exist on the semiconductor substrate prior to the application of the optoelectronic components. During the high temperature step of removing the natural oxide of the silicon, at least the electrical components may be damaged.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to avoid, as much as possible, the removal of the semiconductor substrate from the epitaxy reactor. It is a further object, to avoid as much as possible the high temperature steps discussed above. It is still further object to provide a method, which can be implemented so as to enable mass production at reasonable engineering effort and expense and with maximally replicable component characteristics.

With the foregoing and other objects in view, there is provided in accordance with the invention, a method for producing semiconductor components, comprising the steps of: applying at least one HF soluble masking layer on an epitaxy substrate such that said masking layer defines at least one epitaxy first window wherein said masking layer is not applied; epitaxially growing at least one semiconductor layer in at least one of said first window, said epitaxial growth occurring within an epitaxy reactor; and removing said masking layer through use of an etchant, said etchant comprising at least a fluoride, and said removal occurring within said reactor.

The present invention also comprises a method of producing laterally integrated semiconductor components, comprising the steps of: applying a first semiconductor component on an epitaxial substrate; layering a first HF soluble mask over said first semiconductor component and epitaxial substrate, said mask defining windows on said substrate for application of other semiconductor components; and applying second semiconductor components in said windows.

The present invention further comprises A method for producing semiconductor components comprising the steps of: applying at least one first semiconductor component on an epitaxial substrate; applying n number of masking layers on said epitaxial substrate and first semiconductor component, wherein each of said masking layers defines a window for application of other semiconductor

components and wherein n is a natural number; etching at least one of said n number of masking layers; and applying at least one other semiconductor component in at least one of said windows defined by said etched masking layer.

The corroding of the HF soluble layers takes place in the epitaxy reactor by induction of hydrogen fluoride (HF) or an unstable fluoride combination. The unstable fluoride combination is marked thereby, that it disintegrates by light stimulation or by warming to at least one hundred degrees Celsius as well as it releases hydrogen fluoride. With some fluoride combinations, other or additional gases, so called carrier gases, may be induced. Usually H_2, N2 or Argon is used. The induction of theses carrier gases is necessary for unstable fluoride combinations, but not for hydrogen fluoride. Because many epitaxy reactors consist of quartz glass, which reacts with the corrosive oxide, the reactor walls must be protected from such corrosive gas. This is done preferably by cooling the reactor walls so as to reduce the reactivity of these thermic unstable gases.

Different components can be produced through the use of different HF soluble masking materials, each with different layer thickness. Herein, the different HF soluble masking materials are lifted away in different etching steps without interrupting the process as a whole. As such, during different layering steps, different epitaxy materials can be applied epitaxially. With the use of suitable masking defining components, later lithographic processes can be advantageously reduced. In addition, costs savings may be incurred by avoiding the steps of removing and inserting the substrate into the epitaxy reactor.

According to the method of the present invention, already preprocessed semiconductor components (e.g. electrical components) may be connected with more semiconductor components of another type (e.g. optoelectronic components). To facilitate this advantage, already existing semiconductors components may be selectively covered with a thick HF soluble layer. Areas intended for optoelectronic semiconductor components would then be covered with a thin HF soluble layer. By an in situ etching step, the areas for the optoelectronic components would be exposed, while the electrical components remain protected by a thinner layer of HF soluble masking material.

The invention will now be set out in greater detail below with reference to exemplary embodiments shown in the drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Figures 1a-1c depict a schematic presentation of a first embodiment of the present invention;

Figures 2a-2d depict a schematic presentation of a second embodiment;

Figures 3a-3c depict a schematic presentation of a third embodiment; and

Figures 4a-4c depict a schematic presentation of a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference is now made to the figures of the drawings in which elements that are identical or function identically are identified by the same reference numerals throughout. Prior to the start of any of the methods to be described below, it is within the scope of each to clean the epitaxial substrate, prior to any applications, with the introduction of at least one fluoride based hydrogen fluoride soluble layer. The cleaning may occur within or outside the epitaxy reactor. In figures 1a-1c, an epitaxy substrate 9 is depicted with a masking layer 3 comprising one of a HF soluble material. Such material may be SiO_2 or Si_8N_8. The masking layer 3 defines windows 4. The substrate, if not already present, is placed in an epitaxy reactor. Herein and as depicted in figure 1b, a layering sequence 10 is commenced in the windows 4. The sequence may be a semiconductor laser effected by MOVPE (metal organic vapor phase epitaxy). The application step is further indicated by arrows 11. Next and as depicted in figure 1c, the masking layer 3 is removed by etching 12 of a fluoride combination (for example HF), which may be induced in the epitaxy reactor after the epitaxy. The process temperature lies preferably between 50 and 500°C. The substrate 9 or wafer is now ready for additional processing.

Figures 2a-2d depict procedural steps according to the present invention undertaken to produce a laser structure having an active area 1, a first vertical wave guide 2, and a second horizontal wave guide 8. As a first step and as depicted in figure 2a, a HF soluble masking layer 3 (e.g. SiO_2, Si_8N_8) is directly applied onto an epitaxy substrate 9. The masking layer 3 defines windows 4. Next and as depicted in figure 2b, in an epitaxy reactor a first wave-guide layer 5 is applied in windows 4. An active area layer 6 is applied thereon. Then a second wave guide layer 7 is applied thereon. The first and second wave-guide layers 5 and 7 form at least one part of the vertical wave-guide 2. Next and as depicted in figure 2c, the masking

material 3 is removed through exposure to a corrosive gas. The gas may comprise NF_3 and may be inserted into the epitaxy reactor after the epitaxy together with a carrier gas (e.g. H_2, N_2 Ar, etc.). The temperature within the reactor lies in the range of 50 and 500 °C. Next and as depicted in figure 2d, wave-guide material is applied without prior removal of the substrate from the reactor. Accordingly, the vertical wave-guide 2 and lateral wave-guide 8 are produced.

The application of the present method to integrated semiconductor components is depicted in figures 3a-3c. The components may be electrical and optoelectrical. As depicted in figure 3a, electrical components 13 may comprise transistors, diodes, amplifiers, and the like. Optoelectronic components 14 (figure 2b) may comprise laser diodes, optical amplifiers, light emitting diodes and the like. Returning to figure 2a, electrical components 13 are applied on substrate 9 below HF soluble masking layer 3. The masking layer 3 defines windows 4 along the substrate 9. As depicted in figure 3b, the optoelectronic components are grown in windows 4, per arrows 11. Thereafter and as depicted in figure 3c, the masking layer is removed 12 by induction of a fluoride combination into the epitaxy reactor. Now, the wafer can be further processed with, for example additional, electrical contacts and the like.

Additionally, the above steps depicted in figures 3a-3c may be effected with application of a thicker masking layer 3 on the electrical components than in areas for the optoelectronic components. A masking layer removal procedure in the epitaxy reactor will remove a layer of masking revealing an area for application of the optoelectronic components while leaving the electronic components protected by a remainder masking layer. This procedure has the advantage of additional protection for the electronic components during growth of the optoelectronic components or other intermediary steps envisioned by one skilled in the art.

Figures 4a-4c depict method steps for producing integrated semiconductor components, wherein first, second and third semiconductor components 15, 16, 17 may be interconnected. These semiconductor components may be the same or of a different type. As depicted in figure 4a, epitaxy substrate 9 has a first 18, a second 19, and a third HF soluble masking layer 20 applied thereon. The masks can be of the same or different composition and/or the same or different thickness. Of the masking layers, first mask layer 18 is first applied. This mask layer defines windows where later application of the semiconductor components will be performed. The second masking layer 19, applied next, defines windows where first semiconductor

component 15 will be later applied. The third masking layer 20, defines windows where first and second semiconductor components 15 and 16 will be later applied.

As depicted in figure 4a, the first semiconductor components 15 are applied on the epitaxial substrate 9. Then, as depicted in figure 4b, the third masking layer 20 is removed. In addition, a portion of the second masking layer 19 may be removed. Both removals may be performed by etching, within the epitaxy reactor, by the introduction of a fluoride combination. Next, the second semiconductor components 16 are epitaxially precipitated on the epitaxy substrate 9 in the windows defined by the remaining second masking layer 19. Thereafter and as depicted in figure 4c, the remainder of second masking layer 19 is removed by etching within the epitaxy reactor via the introduction induction of a fluoride combination. Next, third semiconductor components 17 are applied in the windows defined by first masking layer 18 and the already applied semiconductor components. These method steps can be enlarged to incorporate any number and types of semiconductor components. Herein, the number of masking layers and removing steps would be similarly enlarged, according to the guidelines presented above, so as to correspond to the increased number and/or type of semiconductor component.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications would be obvious to one skilled in the art intended to be included within the scope of the following claims.